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ANNUAL REPORT

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GEOLOGICAL SURVEY

FOR THE YEAR 1876.

BY

T. C. CHAMBERLIN,
CHIEF GEOLOGIST.

MADISON, WIS.:
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ANNUAL REPORT.

To His Excellency, HARRISON LUDINGTON,
Governor of Wisconsin :

SIR : — In accordance with the requirements of chapter 292 of the General Laws of 1873, I herewith present a report of the progress and results of the geological survey for the year 1876. As previous legislatures have deemed it injudicious to publish voluminous annual reports, but have wisely made provision for the publication of a final report which shall include all the results of the survey in their most compact and convenient form, it is not thought advisable to extend this report beyond a brief statement of the work of the year, and of the condition of the survey at its close. The labor saved by this brevity has been expended in hastening the preparation and publication of the final report.

Most respectfully,
Your obedient servant,
T. C. CHAMBERLIN,
Chief Geologist.

THE GEOLOGICAL SURVEY.

The direction of the survey was placed in the charge of the writer on the 16th of last February. At that time there remained an area of upwards of 28,000 square miles that had not been examined in detail. The greater part of this area lay in the unsettled forest region of the north, where the most serious obstacles to examination are presented. Not only does the density of the forests make their penetration to long distances from the settlements laborious, but it conceals the outcroppings of the formations, and greatly enhances the labor necessary to make complete investigations. To these difficulties, the little known character of the region, both geographically and geologically, adds many others. Geological reconnoisances had been made along some of the rivers and in the more accessible portions, but even the general structure of large areas was, as the sequel has shown, quite unknown. As this region involved the unascertained limits and relations of both the iron and copper-bearing series, its exploration became the more important. Besides the survey of this large, unexamined tract, it was deemed essential that further examinations should be made in some important regions, which had been previously examined in part, especially the iron districts of Oconto and Ashland counties. There remained of the time for which appropriation had been made, little more than a year, and of the funds, an available amount somewhat less than the allotment for one year.

From these facts it becomes evident to every one, most especially so to those familiar with geological work, or with exploration of any kind in the northern part of the state, that a more than Herculean task was imposed upon the corps. To this was added a little later, by enactment of the legislature, the laborious but grateful duty of preparing and publishing the final report.

The plan of operations for the season was matured with reference to these conditions.

Two purposes predominated: the first being to sieze upon the most important points and lines of investigation, and, from these to extend the work so far as possible; and the second, to so distribute the work as that, if not complete, it should be as nearly as possible just to the several sections. In respect to the latter point, it is to be remarked that nothing short of the complete and thorough investigation contemplated by the act authorizing the survey can be entirely just, since the greater portion of the state has been thus examined.

In pursuance of this plan and the modifications subsequently found advisable, work has been in progress on the Oconto Iron series, reaching out thence westward and southward; upon the Penokee Iron series, with the double purpose of more thorough examination of the known portion, and, of determining the nature of its westward extension; upon the Copper Bearing series in Ashland county; upon the Copper Bearing series in Polk county and its heretofore unrecognized extension through Burnett, Ashland and Bayfield counties to its junction or rather continuation in the Lake Superior series; upon the Paleozoic formations of the St. Croix and upper Mississippi regions, and upon a portion of the Archaean district on the head waters of the Wisconsin river. A little additional work has also been done in the lead region and in the central and southern parts of the state. These several portions of the work will be considered more in detail presently. They are here grouped together as indicating the salient plans and purposes of the year's administration, and because they determined, in large measure, the organization of the working force.

ORGANIZATION OF THE CORPS.

The commissioned members of the corps, R. D. Irving, A. M., E. M., Moses Strong, A. M. E. M., Assistant Geologists, and W. J. L. Nicodemus, A. M., C. E., Topographical Assistant, have retained their connection with the survey as heretofore. Mr. Strong continued his work of previous seasons in the Mississippi regions until July, after which he explored the Copper-bearing series from St, Croix Falls to Lake Superior. Prof. Irving, besides some work in central Wisconsin, continued his examination of the Iron and Copper-bearing series of Ashland county, begun in 1873. Prof. Nicodemus has been actively engaged in compiling the geographical data for the maps, and in drawing them upon a uniform and accurate scale. Each township has been carefully built up from the notes and plats of the original government linear surveys, and the natural features have been compiled from a large collection of state, sectional, county, township and special maps. It is impossible in the present condition of our linear surveys, and of the local maps, to construct absolutely accurate maps, but it is believed that those of the survey will be an important contribntion in that direction. This digression from the subject of organization is rendered pardonable by the fact that I shall not again have occasion to refer to the work of Prof. Nicodemus.

Arrangements were made with Prof. W. W. Daniells, of the State University, who had been chemist to the survey during the first two years, and with Mr. Gustavus Bode, of Milwaukee, who had sustained that relation during the last year, to do such chemical work as might be needed, at specified rates, per determination.

Chas. E. Wright, M. E., an experienced iron expert, was engaged to examine the Penokee Iron range from the gap of the Bad river westward, and to trace out its extension as far as the time and means that could be allotted him would permit.

In 1874, work was commenced in the Menomonee Iron region of Oconto county, under Major T. B. Brooks, C. E., an iron expert and geologist of large experience in the Lake Superior region, but the funds that were apportioned to that part of the work, on the basis of an estimate of its cost, proved insufficient, and the survey was left incomplete. During the following year, the work was not resumed. It was deemed highly important that the investigation of that region should be continued. Circumstances rendered it impossible to secure the personal services of Major Brooks, and the work was therefore placed in the hands of his associate, Mr. Wright, who had assisted in the work that had been previously done, and was thoroughly familiar with the region so far as then explored.

Mr. L. C. Wooster, who had been connected with the survey during the three preceding years, was employed to examine a belt extending from St. Croix and Pierce counties eastward, and lying contiguous to the area surveyed by Mr. Strong.

The commissioners for the survey of a military road from Wausau to the north line of the state, a distance of about one hundred miles, generously offered to furnish supplies and camp facilities for an observer to accompany their party; and Dr. A. C. Clark, of Wausau, was commissioned to this work.

The act authorizing the survey very wisely requires observations on animal life in its relations to agricultural interests; and, in pursuance of this provision, arrangements were made with Dr. P. R. Hoy, of Racine (known throughout the country as an able observer in this department), to report upon the fishes, reptiles and insects of the state, whereby, not only the observations of the year, but the fruits of a life time of earnest study are secured to the state.

Mr. F. H. King, who, as my assistant in previous years, had been engaged in practical observations in this department of the survey, and had accumulated many valuable facts, as heretofore reported, has continued his observations in relation to the food and habits of birds.

In the progress of the survey, a collection of twenty thousand or more fossils had been gathered; many of them new species which required identification and description preparatory to publication, and, to the specimens being placed in the several institutions entitled to them. For this work, the services of Prof. R. P. Whitfield, of Albany, N. Y., an able and experienced paleontologist, who, through former investigations, was thoroughly familiar with the organic remains that had previously been collected in the state, and was thus peculiarly fitted for this work, were procured.

The working force as thus organized stands as follows:

CORPS.

T. C. CHAMBERLIN, Chief Geologist.
R. D. Irving and M. Strong, Assistant Geologists.
W. J. L. Nicodemus, Topographical Assistant.

LOCAL AND SPECIAL ASSISTANTS.

W. W. Daniells, Chemist.
Gustavus Bode, Chemist.
Chas. E. Wright, Iron Expert.
hi t field, Paleontologist.
P. R. Hoy, Ichthyologist and Entomologist.
F. H. King, Ornithologist.
L. C. Wooster, Local Assistant.
A. C. Clark, Local Assistant.

FIELD AND OTHER ASSISTANTS.

D. Caneday,	F. H. Brotherton,	E. M. Hill,
A. D. Conover,	I. M. Buell,	C. S. Bacon,
	C. S. Douglas.	

The following brief reports are intended to indicate the general nature of the work accomplished in the several departments, and to give the more obvious results in advance of the full and matured reports which will be prepared, and which involve an amount of time and labor that it is impossible to give at the early date at which this annual report is required.

WORK IN THE NORTHWESTERN PORTION OF THE STATE.

The nature and results of the survey in the Mississippi region and on the Copper Bearing range, between St. Croix Falls and Lake Superior, is well set forth in the following outline, prepared by Mr. Strong.

RESUME OF OPERATIONS OF THE WISCONSIN GEOLOGICAL SURVEY IN THE NORTHWESTERN PART OF STATE, 1876.

On the 1st of June, 1876, the party in charge of the western division of the state geological survey left Mineral Point to continue the field work in the vicinity of the Mississippi river. Proceeding by land, with the outfit, to Trempealeau, examinations were commenced in the southern part of Buffalo county.

The explorations of the first six weeks embrace a tract of about twenty-five townships, situated in Buffalo, Pepin and Pierce counties, extending along the Mississippi river from Trempealeau to Prescott; forming an area about eighty miles in length and from ten to fifteen miles in width.

Within this tract are included the lower part of the valleys of the following rivers, tributaries of the Mississippi, viz: Trempealeau, Waumandee, Buffalo, Chippewa, Rush and St. Croix. Careful examination was made of their valleys for the purpose of ascertaining the changes they have undergone in the Quaternary period. The Champlain deposits which have been traced at intervals along the

Mississippi valley from the south line of the state, were here found to be much more continuous and well defined, and show conclusively the previous movements of elevation and depression which the country has undergone.

A striking instance of this was seen at Taylor's Falls, on the St. Croix, where the river has excavated "potholes," or wells, in the trap-rock in places now elevated one hundred feet above the present level of the river.

The contour lines of the several formations were accurately traced out and mapped in the above described region; in most places extending as far northeasterly as the limit of the Lower Magnesian limestone. This resulted in the discovery of several new areas of St. Peter's sandstone and Trenton limestone.

In the course of examinations the glacial drift was found to extend as far down the Mississippi river as Town 19, R. 11, W., the most southerly outlying deposit being small and isolated, lying about 350 feet above the river. Proceeding northwesterly from the deposits first discovered, they become more numerous and extensive, and finally unite with the great northern drift area.

The examinations of soils and subsoils, and observations on the animal and vegetable productions, received suitable attention, also a careful account was made of the kind, quality and amount of timber in each township, with a view to furnishing valuable information in the interests of our rapidly increasing immigration.

On the 13th day of July, the outfit was transferred to Messrs. Wooster and Hill, assistants of the survey, for the purpose of completing the general geological examination of St. Croix county and parts of the adjacent counties.

From the 4th to the 15th of July was spent in the examination of the trap rocks of the Copper series, which are developed on a grand scale at the falls of the St. Croix and in the adjacent county. It has long been known that the melaphyrs of the St. Croix were identical in lithological characters with the Cupriferous series lying north of the Penokee Iron range, which have been traced to Kewenaw Point on Lake Superior, and there contain the celebrated copper mines. It was reserved for the present survey to determine the relations subsisting between them, and to discover that the Cupriferous series of Michigan extends in a nearly uninterrupted chain across the northwest portion of the state.

The exploration of this country, hitherto a geological *terra incognita*, was conducted by Mr. Strong in person, assisted by Mr. D. A. Caneday, a veteran explorer and geologist: traversing the country on foot, packing their baggage and provisions and sleeping where-ever night chanced to find them. They started from St. Croix Falls on the 15th of July, and proceeded northeasterly to the northeast corner of Polk county, traversing a belt of country about twelve miles in width, and discovering about forty outcrops of the Copper series, some of them covering an area of two or three square miles. In the vicinity of Clam Falls, large and well defined outcrops of the Copper series were found, and it was here that the true position of the formation and its gentle northward dip were satisfactorily ascertained.

Having completed the work in Polk county, a short expedition was made to Rice Lake in Barron county, in order to visit the quartzite ranges in that vicinity, and the celebrated pipe stone locality whence the Chippewa Indians derive the material for their red calumets. Sufficient was discovered here to establish the existence of the Huronian formation beyond a doubt.

From Rice Lake the survey returned to Clam Falls and proceeded to Nemakagon lake, making numerous examinations on the road. This lake is situated in the southeast corner of Bayfield county and is the principal source of the Nemakagon river. Numerous fine exposures of the Copper series were found in the vicinity of the river, from the lake along the river to the south line of Bayfield county. Specimens of native copper associated with the trap were found in the bed of Nemakagon river, rivaling in richness any from the Lake Superior mines, and apparently not far removed from their native bed.

Having examined the Nemakagon river from the lake to the southwest corner of Ashland county, the explorers went by way of the Chibinissa (big bird) creek, to Frog creek, in T. 42, R. 11 W. In this township many fine exposures of the Copper series were discovered.

The Totogatic river, the principal tributary of the Nemekagon, was next explored from the west line of Ashland county to its junction with the Totogatic Oance. Fine exposures of the Copper series, consisting of melaphyrs and conglomerates, were found at various points, chief among which are the Big Falls, Middle Falls, and Little Falls. Native copper and malachite were frequently found in small quantities in the melaphyrs along the Totogatic river.

The survey then proceeded to explore the Totogatic Oance, from its mouth to the heads of the several small streams which form its sources and its tributaries, including in this examination the country in the vicinity of the Eau Claire lakes and the upper part of the Eau Claire river, and the country lying between the Totogatic and the Totogatic Oance. Almost the entire country was here found to be underlaid by the Copper series, and magnificent exposures surrounded us in all directions. Vast ranges of basaltic cliffs stretched away for miles through this trackless wilderness, opening to the vision of the explorer scenery magnificent and grand.

Concerning these hills, the Indians have many wild and curious legends. Here dwells Wani-Bajou, the aboriginal devil. Here grows the fatal cactus, to tread on which is death.

In the examination of these exposures, many places were found where there were veins carrying small quantities of native copper. Our time did not admit of doing much prospecting, although many places were seen which would doubtless repay work of that kind. The last outcrops of the Copper series found, were near Pigeon Lake, in T. 45, R. 8 W.

They were carefully examined and traced as far eastward as possible. The explorers then proceeded to Ashland and returned home by way of the Lake, having traveled in the course of their examinations upwards of a thousand miles.

Much has been done this summer in the exploration of the Copper series, much also remains that should be done. The general course of the formation across the state has been definitely ascertained, but the details of this formation and its connection with the underlying Huronian are not as well known as they should be, and as the explorations of another year would undoubtedly make them.

The time which the survey could devote to their exploration this summer was not sufficient to examine more than half of the outcrops now known to exist.

The extension of the Kettle River range of the Copper series, which from analogy we might reasonably expect to find parallel to the range discovered this summer, would probably be discovered on further exploration.

The discovery and examination of these ranges of the Copper series is not a matter of mere scientific curiosity; but is a matter of pecuniary interest to the people of Wisconsin. The series is now known to be the same as that containing the copper mines of Michigan, and the discovery of one such mine in Wisconsin would repay a thousand times the cost of geological examination.

REPORT OF PROF. IRVING.

MADISON, Dec. 28, 1876.

Prof. T. C. CHAMBERLIN, *State Geologist:*

SIR: I have the honor to present to you, in accordance with the law, my annual report as Assistant Geologist, for the season of 1876.

The field work under my direction during the past year lay chiefly in Ashland county, where I had been compelled by illness to leave some work uncompleted in 1873. The work in this region was performed during the months of August and early September, which were chosen in preference to earlier months on account of their greater favorableness to work in the woods, and all traveling was necessarily done on foot. In the early part of the season, and again towards its close, some additional investigations were made in Dane and Sauk counties, where a few obscure points needed clearing up before the formations could be accurately mapped. During the spring months, I was engaged, and have been since the close of field work in September, in the preparation of the text and illustrations of that portion of the forthcoming volume of the Reports of the Survey in which the geology of Central Wisconsin will be described.

Since the present year is, according to the organic law of the survey, the last of its existence, and since no reports have been printed heretofore, it may not be inappropriate to summarize here very briefly the results of the field work under my charge for the four seasons of 1873, '74, '75, and '76. The different regions in which I have made investigations may be designated as Central Wisconsin, and Northern Wisconsin; the former district including all or nearly all of Dane, Columbia, Sauk, Juneau, Adams, Marquette, Waushara Portage, Wood, Clark, and Jackson counties, central Marathon county, and that portion of Green Lake county north of the Fox River; the latter embracing Ashland, and small portions of Lincoln and Bayfield counties. The results of Mr. E. T. Sweet's investigations on the Copper Range of Douglas county were incorporated with my report for the year 1873, but I have not been in that region myself.

In CENTRAL WISCONSIN the various Silurian formations have been mapped in detail, so that the Atlas Maps now in the hands of the engraver will show the exact distribution of the various limestone and sandstone beds. Careful barometrical observations have been made throughout the whole region; these have given a basis for the construction of the topographico-geological cross-sections that are attached to the Atlas Maps, as also of those that will be included in the text of Volume II of the Reports. These cross-sections show the amount of denudation at a glance, and make it possible to ascertain the thickness of the various layers under any given point. Each one of the Silurian formations has been closely studied with regard to its elementary stratification, fossil contents, materials of economic value, and relation to the surface soil; and the results of this study described for publication.

The crystalline or Archæan rocks—the most ancient in the state—have also been carefully studied, and the bounding lines that lie between the areas over which they are the surface rocks, and those occupied by the Silurian terranes, mapped as nearly as the nature of the case will permit. The Archæan rocks occur in one great mass which occupies most of the northern half of the state, and again in a number of isolated areas rising through the horizontal Silurian strata. Of these detached areas, one of the most interesting is that including the quartzite ridges of the Baraboo river in Sauk and Columbia counties. The structure of these ranges, and the geological relations of the rocks composing them, have now for the first time been made out definitely. Other detached areas of Archæan rocks occur in northern Columbia, and in Marquette, Waushara and Green Lake counties, over a belt of country twenty-five miles in width, and trending N., 32° E. These areas are all much smaller than the Baraboo ranges, but belong to the same great formation. They are either of granite or quartz-porphyry. This formation appears, without much doubt, to be the equivalent of the series of rocks in which the iron ore beds of northern Michigan and northern Wisconsin are found. Specular iron is found in small quantities associated with the quartzites of the Baraboo.

The loose materials that everywhere load the surface of the state, except in its western and southwestern portions, have been studied both in their scientific and practical bearings. These materials have been brought from the northward by glaciers, several of which have traversed the state in different directions, or rather in directions not exactly parallel. The exact course of the Central Wisconsin glacier has been well made out by its markings upon the rocks, and the nature of the materials it has brought. This glacier had its western limit not far from a north and south line drawn through the heart of the state. The limit has been traced, being well marked by a change in the topography as it is crossed, and by the cessation of the drift materials.

The materials of special economic value occurring in the Central Wisconsin district may be briefly enumerated as building stones, ornamental stones, kaolin or porcelain clay, quartz rock, brick clay, limestone for burning into lime, limestone for use as flux in iron smelting, glass sand, peat, iron ores.

The building stones are of three general kinds: sandstones, limestones and granites. All of the horizontal strata are made use of for building purposes, the Silurian section of the region being thickly dotted with quarries; but certain horizons yield stone of especial value. Excellent sandstone occurs especially at two horizons, one of these being in the middle of the Potsdam series, the other immediately beneath the limestone known as the Lower Magnesian. The stone from the first named horizon is a light colored, much indurated rock, composed of rolled grains of glassy quartz. It is quarried near Packwaukee, Marquette county, Baraboo, Sauk county, Stevens Point, Portage county, Grand Rapids, Wood county, and Black River Falls, Jackson county; and undoubtedly exists very largely over the state. The stone from the last named horizon is a dolomitic, light yellow to buff colored, sandstone, containing about ten per cent. of dolomitic matter. It is quarried largely near Madison, and occurs to a large extent over the region of the Four Lake country. The limestones of the Lower Magnesian and Trenton groups are much used for building, but certain horizons in the Lower Magnesian appear to yield an unusually good material. The granites and allied crystalline rocks that are adapted to use as building or ornamental stones are quite plenty among the Archæan terranes of Wisconsin, but those red granites that occur on the Wisconsin, Yellow and Black rivers deserve especial mention. These consist of bright red cleavable felspar, mingled with hyaline or smoky quartz in such a manner that they are capable of receiving a very high polish. They do not show any tendency to decompose, and are easily dressed. Specimens of the red granite from Yellow river, displayed with the Centennial collections, attracted very markedly the attention of experts, as an extraordinary stone.

Limestone suitable for use as a flux has hitherto been a disideratum in Wisconsin, many of the furnaces in the eastern part of the state importing their material from Ohio. Such a limestone however exists in certain layers of the Trenton group, as first shown by analysis made on specimens from the town of Bristol, Dane county. Glass sand exists quite abundantly in certain layers of the Potsdam series, but more especially in the bed known as the Madison Sandstone, immediately underlying the Lower Magnesian Limestone.

One of the most valuable mineral materials existing in the state is the kaolin or porcelain clay of Wood and Jackson counties. This, as to its abundance, quality, nature and mode of occurrence, has occupied much of my attention, and a very large number of analyses have been made of kaolin samples. It appears to be quite certain that a large amount of kaolin exists, which, if properly treated, will make a fire brick of extraordinarily good quality, and even fine pottery. The quartz rock needed for mingling with this clay to make refractory brick, exists in abundance and of the needed quality, at numbers of points — the Rib and Mosinee Hills, near Wausau, being the most noteworthy of these.

The iron ores of central Wisconsin come chiefly under the head of bog ores. These appear to exist in some abundance underneath the great marshes of Wood and Juneau counties. Several places visited show ore of excellent quality in abundance. Analyses of these ores are ready for publication.

In **Northern Wisconsin** we note a very different rock structure from that of any other portion of the state. Here are four great groups of rocks, the Laurentian, Huronian and Copper Bearing Series, and the Lake Superior Sandstone; the order of mention being that of relative age, and also of relative distance from the shores of Lake Superior. The first named, so far as yet known, carries no metallic ores; the second contains a large amount of the magnetic and specular oxyds of iron; the third carries copper and possibly some silver; whilst the fourth is again without metallic ores, but yields a sandstone for building which is of unusual value, and has been largely exported. These four entirely distinct systems are crowded into one county, which they cross in parallel belts, having a trend from north of east to south of west. Each series appears to lie upon its predecessor unconformably, and all but the last named have thicknesses measured by thousands of feet, and are tilted on end. The work done on these rocks has consisted first, in mapping their respective surface distributions; and, secondly, in the detailed study of the several groups. More attention has been given to the Huronian or Iron Bearing group, than to the others. This group is composed of a succession of beds of marble, quartz, silicious schist, quartzite, magnetic schist, or lean magnetic iron ore, diorite, black slate and gneiss, and is over 5,000 feet in thickness. The middle portion of the series constitutes the bold ridge known as the Penkee Iron Ridge. In the gaps made through the range by northward flowing rivers, and all along its southern face, the outcrops of rock and lean ore are numerous. One of the largest of these gaps is that at Penokee. Here, a long time was spent in making a topographical survey, in order that the exact succession of beds might be made out. This succession of layers is of importance, because, judging from the succession in the Marquette Iron District, where the same rock series holds the iron ore, a certain layer holds the richest ore. Along the Penokee range, outcrops of this horizon have not been found, it being largely buried by drift. The iron belt has been traced all across Ashland county, and across the Montreal river into Michigan. At points all along the belt ore outcrops have been examined and sampled for analysis. The result of these analyses shows that much ore exists, having between 40 and 50 per cent. of metallic iron. It is quite probable that richer ore exists, but further explorations will be needed to demonstrate the fact.

The copper-bearing belt of Wisconsin is the direct continuation of the belt which carries the copper and silver of Keweenaw point, Portage lake, and Ontonagon. Where it crosses into Wisconsin, it is at the lake shore, from which, however, it rapidly recedes, becoming at the same time much thinned and drift-covered. It is best exposed in gorges made by the rivers which cut across the layers. The gorge of the Montreal river is the most remarkable of these. Here, for many miles, the river passes between walls of rock, on which are seen the successive layers of the series, standing vertical. Ascending the river from its mouth, at right angles to the general strike of the layers, we find 10,000 feet of sandstone; 300 of alternating sandstone and soft shale; 2,000 of conglomerate; 800 feet of alternating melaphyr and shale or sandstone; and then the great thickness of melaphyr which constitutes the body of the series. The section bears some resemblance to that on Iron river, in Michigan, where silver is obtained from the eastward continuation of the same belt. It is supposed that the exact horizon of the Iron river silver, which is found in sandstone and shale, exists on the Montreal river in the bed of shale lying next north of the great conglomerate. The shale is stained with numerous fine points of the green copper carbonate. Samples were selected for assaying, which have not yet been examined.

ROLAND D. IRVING,
Assistant Geologist.

The extent of the explorations in Oconto county and on the western portion of the Penokee range, by Mr. Wright, are detailed in the following report:

MR. WRIGHT'S REPORT.

Prof. T. C. Chamberlin, *State Geologist:*

Dear Sir: In compliance with your request, I herewith hand you a brief statement of my field work for the past season, in advance of a detailed report, wherein the results will be more fully developed. Ever since my return from the Penokee district I have been busily engaged upon the results obtained in regard to that region, but as yet have only partially completed the task, and consequently have not even gone over the notes taken in the Menomonee district. A general outline of the work performed in this latter region may be briefly stated as follows:

We started from Bad Water village on the Menomonee river, and went up the stream to the headwaters of the Brule river, in town 41, range 13 E. From there we crossed over in a southerly direction to the head waters of the Pine river, and then down this stream to its mouth on the Menomonee.

On this voyage of over a hundred miles, we saw a number of ledges of rock and collected specimens from each. The general trend or strike of the Huronian series, say west of range 17 E., is apparently N., 60° W., and it may be safely affirmed that valuable iron deposits will eventually be discovered within this area.

When we arrived in T. 39, R. 17, it was our intention to have done some detail work, and then to have gone across the country to the Peshtigo and Oconto rivers to examine this portion of Oconto county, but I regret to say even more than any one else possibly can, that an unfortunate sun stroke received during one of those intensely hot days of last July, just before reaching La Salle's homestead, rendered this latter portion of our work at the time impossible. Being thus suddenly disabled almost at the beginning of our work, I was compelled to send my assistant, Mr. F. H. Brotherton, and an Indian, from the lower Quineseck Falls on the Menomonee, to the Peshtigo. Mr. Brotherton carefully located all the outcrops he saw, and collected specimens from each. The rocks of this section are chiefly granites and quartzites. These results will be fully considered in the regular report.

Having now in a cursory manner given an outline of the Menomonee work, we will proceed at once to the Penokee range. Agreeable to my instructions to trace the Lower Huronian or Iron Bearing series as far westward or southward, as a limited time would permit, we began our task just west of the "Gap." The plan adopted was to cross the Lower Huronian every quarter or half mile, wherever there was a prospect of finding outcrops of rocks, and to take magnetic observations with the Solar-Dial Compass and Dipping Needle on these lines, at every twenty-five, fifty and one hundred paces, depending on circumstances.

The lower belts of magnetic schists outcropping at the gap, constitute what is known as the Penokee range. The ridge is from 150 to 200 feet high. In places, it is quite narrow, and at others its crest is broad, measuring in some instances three hundred paces across. From just west of the Gap the range lies in nearly a due west course for two miles, and passes through section 15, T. 44, R, 3 W., close to its north line, and so on, half way across section 16. Here it bends somewhat to the southwesterly and continues this course through section 17, leaving the section about 500 paces north of the southwest corner. Entering section 18, the range is not as regular, but finally passes out just south of the southwest corner of the section. The range extends into sections 24 and 13, T. 44, R., 4 W., only 300 paces, when it suddenly "drops down" one hundred feet or more. In these sections, the formation makes a double turn, forming a letter S. There are some fine exposures of magnetic schists here, where this singular structure may be nicely observed. In this section, we found some float fragments of very fair granular magnetic ore. The range, now a low ridge, crosses the west line of section 13, at the quarter post and then swings gradually round to a southwest course. The last outcrops of rock here to be seen are only 250 paces from the quarter post. Along the northwest shore of Bladder lake are several exposures of green stone apparently nonconformably overlying the Iron Bearing series, and are probably one of the lower members of the Upper Huronian or Copper series. The ground, after leaving the west quarter post of section 13, very soon becomes low and wet, and the range, no longer visible, must now be traced by the Solar-Dial compass and the Dipping needle. Placing these trusty guides upon the invisible trail, we followed their silent indications.

The line of magnetic attraction, though faint, piloted us to the south quarter post of section 14, then through the northwest quarter of section 23, and across 22, entering section 21 near its southeast corner, then coursing along not far from the south line of 21 to its southwest corner. We continue in a southwesterly direction, then northwesterly through the north half of sections 29 and 30.

Just north of the northwest corner of section 30, is a ledge of granite, and near the north line of the northwest quarter of section 19, are some ledges of greenstone.

The line of magnetic attraction crosses the southwest quarter of section 19, and northwesterly through section 24, T. 44, R. 5. In the north half of section 23, and the south half of section 14, the Iron range reappears at the surface. Here we find some fine exposures of magnetic schists, granites, and diorites. Pursuing our westward course, we pass the south quarter post of section 14, and follow down the Morengo river, along what appears to be the junction of the Huronian and Laurentian rocks. Arriving at the southwest corner of 14, we continued westward. A little east of the south quarter post of section 15 is a ledge of magnesian limestone, one of the lower members of the Iron series. About 400 paces west of this ledge is another similar one. Entering section 16, we find in the south half numerous high ledges of the Iron Bearing series. The range forms a high, broad ridge, and commands a fine view of the country.

The magnetic schists, diorites, and hornblende rocks are the principal rocks. Leaving the section at its southwest corner, we are compelled again to resort to our needles. The line of attractions is somewhat crooked, crossing first the south line of section 16, then apparently turning northwest again into section 17, and then again southwesterly, leaving section 17 near its south quarter post.

In the N. W. ¼ of the N. W. ¼ of sec. 20 are several ledges of diorite and hornblende rocks. The line of attractions crosses the west line of sec. 20 about four hundred paces south of its northwest corner, and follows along the north shore of a small lake, then turning to the southwest again, we cross the west line of sec. 19, six hundred paces from the northwest corner. Entering T. 44, R. 6, its course varies but little from a southwesterly direction, and we trace it through sec. 24, the northwest quarter of sec. 25, and into sec. 26. In this section we find some low ledges of magnetic schists and diorites. The line of attraction is a very irregular one, but finally leaves the section about five hundred paces north of its southwest corner, and then courses along near the south shore of a small lake. Changing again to the southwest, it enters sec. 34 about seven hundred paces west of its northeast corner. The line of attraction takes now a more southerly course and crosses a small lake, then over a low piece of ground to Nemakagon lake. We found them again on a narrow point of land just east of where the south quarter post of sec. 34 would be. From this point, we traversed the lake in all directions, on a raft and in a canoe, seeking to follow along the iron belt beneath the bottom of the lake, but the magnetic attractions were too faint. Then we traveled along on the north, west and south shores of the lake, and finally detected some feeble magnetic attractions near the lake dam on Nemakagon river in the S. E. ¼ of the N. W. ¼ of Sec. 8, T. 43, R. 6 W. We soon found that this was a broad belt of magnetic attractions, and as these were not definite enough to trace, we went to the southwest corner of sec. 7, T. 43, R. 6, and proceeded south three hundred paces when we reached their southern limits. Changing our course to southwest, we continued to the north and south center line of sec. 13, then south to the south quarter post of the section, then due west for one mile and a half to the southwest corner of sec. 14. The magnetic attractions began to show themselves again here, and as we turned north, they became much stronger. Two hundred and fifty paces north and one hundred paces west of the above corner is Pendleton's logging camp, which is now occupied by Wm. Chalmers.

From the men here, we learned of some outcrops about two miles down the river in the northwest quarter of section 21, town 43, range 7 west. Meandering the supply road with our solar dial compass, we proceeded to the ledges, noting carefully the magnetic attractions, which continued along the entire route with variable intensity. The ledges were massive green stones belonging to the Copper series, and just south of them are found some low exposures of granite. From this point, we could detect no magnetic attractions, for one mile and a quarter south. My impression was then, and is now, that the Iron Bearing series is covered by the Copper range, and that this granite belongs to the Laurentian, which supposition would best explain several facts obtained in the field, and others observed in the lithological characters of the upper and lower granites, and which will be fully considered in my regular report. This is as far as our limited time would allow us to trace the Iron range. It has been my constant aim, and still is, to correlate the Penokee series of rocks with those of Michigan, and there exists in my own mind no reasonable doubt that the rock formations of these two districts are the equivalents of each other. In the Penokee, we have the limestone and quartzite members; the belts of magnetic schist interlaminated with the green stones, also the black slates and mica schists, all occupying relatively the same stratigraphical position as in the Michigan series.

Very respectfully, etc.,

CHAS. E. WRIGHT.

MARQUETTE, Mich., Dec. 10, 1876.

On the head waters of the Wisconsin river, Dr. Clark made a series of observations, which have not yet been reduced to a formal report. The following letter, giving an informal report, though not prepared for this place, clearly sets forth their nature and general results:

WAUSAU, WIS., June 24, 1876.

Prof. T. C. CHAMBERLIN, *Beloit*, *Wis.:*

DEAR SIR: I forward, by American Express, notes, etc., containing the observations made on the line of the "Military Wagon Road Survey," in accordance with your instructions. The plats I will forward in a few days, as I wish to compare them with the maps of the surveyor, which are not quite ready yet.

I left Wausau on the 5th day of May and commenced field work at Callon's Mills, between this point and Jenny, on the 6th. I returned on the 31st, the survey having been completed in much less time than we supposed it would take.

The geological information secured has not been of so positive a character as I was led to anticipate, the reason being that nearly the whole of the region visited is covered by a deep superficial deposit of drift. This was the case in the entire region visited above town 34, through range 7. The notes have been written either on the tramp or in camp after the fatigue of traveling all day through a Wisconsin forest. If they add anything to the knowledge of this region, I shall be satisfied. I have kept a record of native vegetation in a time book, it being conveniently ruled for the purpose. The list sent is a duplicate of this. It is not so complete as I could desire, but vegetation has been very backwark in this part of the state on account of the lateness of the season.

I have endeavored to keep the barometical record with all possible care and exactness. I believe I have given all the considerable elevations and depressions. I have used the inner scale of the barometer in every case.

The topography of the region between the north part of town 34 and the state line is of the same general character. It is the kind of surface you refer to in your instructions as "characterized by circular, oval, elongated, or irregular depressions (kettles), with and without water, and by hills, hillocks (inverted kettles), and serpentine drift ridges." You can see by some of the rough sketches I have made, that they cannot be accounted for by the *ordinary* action of running water. You were correct in surmising that the lakes of the region occupy such depressions, for they do so in every instance.

The most striking peculiarity observed in this region was the water system, which is carried on in many instances without the aid of running streams, the porous nature of the formation admitting of a sort of circulation through the earth itself. This is seen in the number of lakes of clear, pure water, surrounded by high banks, with no visible inlet or outlet. This would seem to imply a considerable depth to this drift formation. I think this will also prove to be one reason why the water in the Wisconsin river keeps comparatively high in spring, long after the snow and ice have disappeared.

Judging from barometrical observations, as well as from such information as I could obtain from members of our party who were familiar with the region, I believe we reached the highest general elevation in the state in Town 43, Range 7. There may be higher points than those we crossed however.

No deposits of either peat or marl were observed, though they were carefully looked for in favorable locations. The samples of soil sent may have caused you to smile, they being somewhat Homœpathic. But when you reflect that everything had to be packed for many miles on foot, through forest and swamp, you will see the reason for taking so small a quantity. They are merely intended to give you an idea of the general character of the soil in the region. The acid tests which you suggested were made, I believe, at every camp, and occasionally elsewhere.

The region is evidently wholly of drift formation. And now, comparing by the aid of memory the drift in the neighborhotd of Wausau with that of the most northerly part of the region visited, I can discern no essential difference in their constituents. I am led to the conclusion that the drift of the region came from a great distance. This, however, I will leave to those who are more capable of determining. From the foregoing, you may know that no minerals of economic value were met with. Not many sections of drift were exposed, and such as were observed were in the neighborhood of running streams, and not far above their present level.

These sections usually showed an assorted or stratified arrangement of materials, the finer and coarser constiuents being found in alternate layers (nearly or quite horizontal). Away from the vicinity of streams, no good sections were observed.

Glacial grooving and striæ were not met with. This region is not favorable for such observations.

Much pains was taken to discover rock in place. In situations at all favorable, I reconnoitered to a considerable distance on each side of the line of survey.

All the members of our party were on the lookout as well, but without success; nothing but boulders was observed after leaving Skanawaum Station. The specimens sent were probably all taken from exposures already examined by your corps.

At the end of the notes, I have given a list of the animals, etc., observed. I should like to have had more time to examine the fish found in these lakes. I think, however, they are similar to those found in the lakes in the southern part of the state.

Yours truly, A. C. CLARK.

PALEONTOLOGY.

In the examination of the collections of fossils of the survey, Professor Whitfield has recognized upwards of 150 species entirely new to science. Of these, a portion of the more perfect and interesting have received preliminary descriptions. In several instances much new light has been thrown upon the character of problematic fossils, or of little understood forms, or new features in the structure or relation of old species discovered. The vertical range of several species has been extended beyond the limits previously recognized, and valuable contributions made in respect to the distribution and associations of others. The entire number of species found in the collection is above 750, while the entire number of specimens that were examined is estimated at above 20,000.

By the examination of these, it was found that no good reason exists for the separation of the lower dolomite beds of the Upper Silurian from the Niagara group and recognizing them as Clinton, since they are firmly linked together by their organic remains.

It was further found that the Guelph horizon is distinctly recognizable in eastern Wisconsin. Evidence was also found rendering it probable, though perhaps not demonstrative, that the slaty limestone on Mud creek, near Milwaukee, and the formation in the bed and adjacent banks of the Milwaukee river above the village of Waubakee, in Ozaukee county, belong to the lower member of the Lower Helderberg formation, the position to which the cement rock near Milwaukee was erroneously referred by my predecessor. It was shown still further, beyond all question, that the cement rock belongs to the Hamilton period of the Devonian age, the position to which the writer has uniformly referred it, and which reference was assailed at some length in the annual report of my predecessor.*

REPORT OF DR. HOY.

At my request, Dr. Hoy has prepared a few statistics indicating something of the fullness of the material he has gathered, and is elaborating

Prof. T. C. Chamberlin, *State Geologist:*

Sir—I have the honor to offer the following brief abstract of a full report which I propose to make on the Reptiles, Batrachians, Fishes, and Insects found in the state.

Wisconsin has a rich fauna. Fish and insects are especially numerous, a remarkable number of southern forms of them inhabiting the state. This peculiarity is owing to the summers being warmer here than they are in the same latitude east of the great lakes. I shall be able to furnish a nearly complete list of the reptiles and batrachians, and anticipate but a few additions in these departments.

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*The managers of the Milwaukee Cement Company submitted fossils from the cement rock to Prof. H. L. Kendrick, of West Point. The following is an extract from his reply, recently received: "After an examination of the fossils found in these cement rocks (Milwaukee), I am inclined to agree with your geologists who assign them to the Hamilton date. I ought to add in all frankness, that I should differ with your geologists in a case like this with much hesitation. In addition to their well known ability as experts, they are undoubtedly well acquainted with the overlying and underlying strata."

We have 39 known species of reptiles, viz: 10 turtles, 4 lizards, and 25 serpents. Of batrachians we have found 10 frogs, and 11 salamanders. In studying the fishes, I am happy to state that I have been greatly assisted by Prof. Jordan, of Indiana, and other eminent Ichthyologists, so I hope that the report will not only be of value to the state, but of interest to science. We have catalogued not less than 150 species of fish, six of which at least are new. My list of insects is not in such a forward state that I can enumerate the species. As an earnest of what you may expect, however, I will say that of Lepidoptera, we have taken 111 butterflies, 26 Sphingidæ, and of the family Noctuidæ no less than 43 species belonging to the genus Catacola alone. P. R. HOY.

RACINE, Dec. 28, 1876.

ORNITHOLOGY.

The main object of the observations that have been made on the birds of the state, in connection with the survey, was to determine as fully and accurately as possible the food and habits of those that spend any noteworthy portion of the year with us, for the purpose of ascertaining their character as beneficial or injurious to agricultural and horticultural interests. The mistakes that have been made in older communities, in the introduction as well as destruction of birds, have shown that in addition to all that is now known, fuller and more accurate knowledge, as well as wiser conclusions on this important subject, are needed.

Aside from ordinary observations, the main method relied upon has been to examine the contents of the digestive organs of birds taken at different times of the day and seasons of the year, as also at different ages and under varying circumstances. In pursuance of this method, Mr. King has analyzed during the summer the contents of the digestive organs of 688 birds, representing 171 different species. Altogether he has made such observations on over 1,000 birds, representing 180 species. This includes nearly all those that remain for any length of time in the state, or have any important practical interest, although a considerably larger number pass the state in migration, or occasionally visit it. These observations have been carried on at widely separated localities, that local peculiarities, if they exist, might be avoided.

Concerning the personal labors of the Chief Geologist, it is fitting that I should speak as briefly as official duty and legal requirement will permit, trusting that the progress and results of the work as a whole will best indicate what degree of faithfulness and good judgment, or otherwise, has been exercised in their discharge. The double duty of prosecuting the survey, and of preparing and supervising the publication of the report, has rendered these labors unusually exacting, and there has been given to them, except during an interval of severe illness, the most complete and unremitting devotion of time and strength. An effort has been made to give personal assistance and supervision in the field as far as possible, and to become practically familiar with the work in all its departments. The remote situation of the several points where presence was needed has added much to this labor, as will be evident from the fact that a distance of about five thousand miles has been traveled in the discharge of the duties of the year.

Without trespassing upon the province of the assistant members of the survey, it may be remarked that a more favorable opinion of the natural resources of the several regions visited was derived from these examinations than had been previously entertained.

PUBLICATION.

The law under which the survey is being conducted requires two classes of reports, annual and final. The former are intended to show the progress and results of the work of each year, while the purpose of the latter is to gather together in the most systematic and convenient form the mature results of the whole work.

Voluminous annual reports have been made in previous years, but the legislatures to which they have been submitted have thought it best to defer their publication. The legislature of last winer passed an act providing for the "preparation, publication and distribution of the final report." Immediately upon the passage of this act, which was approved March 6, the members of the corps were called together and the details of the plan of publication fully discussed and determined, and the work of preparation at once entered upon.

It was found that although a generous appropriation had been made, it would be insufficient to publish the maps and sections on the large scale that had been used in the annual reports, and it was found necessary to reduce the scale as much as possible, consistent with distinctness and accuracy. This necessitated the redrawing of all the maps and sections, a work of very great labor, but one which reduced the cost of publication several thousand dollars.

An analogous fact was true of the manuscript, which, as already implied, was in the form of annual reports that required to be combined, reärranged and systematized, necessitating the rewriting of the greater portion, while all those portions which belong peculiarly to a final report had to be originally prepared. Owing to the large amount of field work to be done, it was deemed necessary that this preparation should be done in subordination to that work, however desirous the corps might be for the early appearance of the report. It was expected, however, that one volume would have been ready somewhat sooner than is now probable, an expectation that would doubtless have been realized, had it not been for the loss of time consequent upon my illness. Maps were given the engravers on the 11th of October, and they have been actively engaged ever since, and the work will be pushed forward as fast as is consistent with its proper execution. The arrangements for publication made by the Commissioners of Public Printing will be found stated in the report of the Secretary of State.

The character of one volume, which, from its nature, it was thought best to designate Volume I, was determined by the law of publication, and as it involved general conclusions that could only be arrived at after the close of field work, Volume II, which relates to the southern portion of the state, was put in preparation.

The following is an outline of the report:

VOLUME I.

The nature and design of the first volume is somewhat new. It is intended to accomplish four objects: First, by a suitable presentation of the general geology of the state, accompanied with elementary and explanatory matter, to place the whole report within the easy comprehension of intelligent citizens who have no technical knowledge of geology. Second, to convey to the people of the state information and directions as to how to detect, test and utilize the natural resources of the state, information which is scattered through a large number of treatises, practically inaccessible to them, and not specifically applicable to Wisconsin, if obtained. Third, by giving a brief, clear history of the formations of the state, adding a sketch of those not found in it; to furnish an elementary text book for the schools of the state, founded upon home geology, and rendered practical by the information above mentioned. And fourth, by furnishing lists of the plants and animals of the state, giving the food and habits of the latter, and designating their character as friends or foes, to assist agriculturists and those engaged in allied industries in their conflict with their enemies in the animal kingdom. The contents will be substantially as follows:

PART I. LITHOLOGICAL AND STRUCTURAL GEOLOGY.

I. Such chemical facts as are necessary to the understanding of the reports. By J. H. EATON.*

II. A clear and simple description of all the minerals found in the state, and the methods of determining them. By J. H. EATON.

III. A similar description of the rocks of the state. By J. H. EATON.

IV. A brief elucidation of structure and metamorphism. By R. D. IRVING.

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*It is a subject of profound regret that the recent and much lamented death of Prof. Eaton will necessitate the completion of his work upon this and the two following topics by other hands:

PART II. HISTORICAL GEOLOGY.

V. An historical sketch of the formations of the state, involving a description of the methods of formation, a concise statement of their leading characteristics, and a very brief outline of the formations wanting in Wisconsin, thus forming an epitome of geological history. By T. C. CHAMBERLIN.

PART III. ECONOMIC GEOLOGY.

VI. IRON ORES. Practical information as to how to explore for iron, how it occurs, how to distinguish the several kinds, the use of instruments, what are trustworthy indications, and what not, what amount and what purity are necessary to give value, how reduced, etc. By R. D. IRVING.

VII. LEAD ORES. Developed in essentially the same method as indicated in the preceding, By MOSES STRONG.

VIII. ZINC ORES. Development similar to the last. By MOSES STRONG.

IX. LIMES AND CEMENTS. Practical instruction on the proper quality of rock, and methods of detecting and testing it and of reducing and using the limes and cements of Wisconsin. By W. J. L. NICODEMUS.

X. BRICK, POTTERY, KAOLIN AND OTHER CLAYS. This and the following topics are to be developed on the same general plan as the preceding. By R. D. IRVING.

XI. PEAT. By T. C. CHAMBERLIN.

XII. CRANBERRY MARSHES AND CULTURE. By T. C. CHAMBERLIN.

XIII. NATIVE WATERS, ARTESIAN WELLS. By T. C. CHAMBERLIN.

XIV. SOILS. By T. C. CHAMBERLIN.

PART IV. PLANTS AND ANIMALS.

XV. LIST OF MAMMALS, giving their food, habits and character as friends or foes to man. By MOSES STRONG.

XVI. BIRDS, as above. By F. H. KING.

XVII. REPTILES, as above. By P. R. HOY.

XVIII. FISHES, ditto. By Dr. HOY.

XIX. Insects. By Dr. Hoy.

XX. A List of the Plants of Wisconsin. Prepared from the Papers of the late Dr. I. A. Lapham.

Owing to the necessity of finishing field work before the completion of this volume, the second volume will precede it in publication.

VOLUME II.

The contents of this volume will be as follows:

I. Reports of Dr. I. A. Lapham, Chief Geologist in 1873 and 1874.

II. Report of Dr. O. W. Wight, Chief Geologist in 1875.

The above are annual reports of progress for the years indicated, but as they constitute the only manuscript which their authors have left to the survey, it is but just that they should find a place here.

III. Geology of Eastern Wisconsin, by T. C. Chamberlin.

This will consist of a complete report upon about 12,000 square miles adjacent to Lake Michigan, including twenty-one entire counties and parts of four others. The following are the leading topics:

Topography. General causes of surface irregularities, preglacial, glacial and post-glacial. Salient surface features and their history. Present and possible utility. List of elevations.

Hydrography. The great and minor systems of drainage and their peculiarities. Explanation of the strange courses of many of the streams. Relations of drainage to (a) Agriculture, and (b) Water power. Estimates of the water power of the district. Amount yet unused. Possibilities of increase and control. Lake systems. Water supply. Systems of springs. Medicinal springs. Analyses. Changes in hydrography of the district. Its cause and warning.

Artesian Wells. Description and explanation of the numerous systems. Where obtainable.

Native Vegetation. Nature, object and value of the observations made. Relation to geological formations. Sixteen vegetal groups, described and mapped, and their climatic and agricultural significance pointed out. Relations to the soil. Timber. Cranberry marshes.

Soils and Subsoils. Origin and nature. Relations to geological formations. Special description of the nine classes of the district—areas occupied by each; analyses; their enduring fertility; comparison with areas occupied by the vegetal groups; deductions.

Quaternary Formations. Contour of rock surface, polishing and striation Two great systems of grooves. The drift movements they indicate. A full description of the following formations, including many new facts that elucidate the method of their formation and the history of the Quaternary age: The "Kettle Range," the "Pots and Kettles," the Blue Bowlder clay, the First Beach deposit, the Lower Red clay; the Second Beach deposit, the Upper Red clay, the Third Beach formation, the Modified Red clay, the Fourth Beach formation. Recent erosion and deposit, encroachment of Lake Michigan. Industrial importance of these formations, peat, magnetic iron sand, brick and potters' clay, marl, etc.

Archæan and Paleozoic Formations. A detailed description of the character, area, magnitude, relations, dip, economic value and organic contents of the following formations as they occur in the district: Laurentian and Huronian rocks, Potsdam sandstone, Lower Magnesian limestone, St. Peters sandstone, Trenton limestone, Galena limestone, Clinton iron ore, Niagara limestone, including the Racine and Guelph limestones, the Lower Helderberg and the Hamilton Cement rock. Among the new and more striking facts that are included here, may be mentioned the remarkable billowy surface of the Lower Magnesian limestone, and the peculiar character of the rock mounds causing it; the quasi-unconformability of the St. Peters sandstone to it, the extremely varying thickness of the latter, its conglomeritic character in some portions; the fossils first found in it; the change the Galena limestone undergoes; its extension, as modified, into Michigan; the change the Niagara formation undergoes midway the district; its four subdivisions at the south and six at the north, the line of barrier reefs of the Niagara age, fifty miles or more in extent; the discovery of new localities; the correction of previous erroneous references, the facts relating to the so called Salina formation and the age and character of the Milwaukee cement rock.

IV. GEOLOGY AND TOPOGRAPHY OF THE LEAD REGION, by MOSES STRONG.

This will be a complete report on the counties of Grant, Iowa, La Fayette and Green, within which limits the productive lead region of Wisconsin is contained.

In it the following subjects are discussed :

General Information respecting previous publications and surveys ; explanations of maps and sections ; barometrical observations and elevations of important points above lake Michigan and above the sea.

Topography — General features of the country ; distribution and location of the watersheds ; direction and formation of the streams, springs and wells ; areas of prairie and forest ; mounds, sinks, and their formation.

Surface Geology — Different kinds of soil and subsoil, and their distribution ; brick clay ; the drift and its western boundary line.

Geological Formations, including the Potsdam sandstone, Lower Magnesian limestone, St. Peter's sandstone, Buff and Blue (Trenton) limestones, Galena limestone, Cincinnati group, Niagara limestone. The foregoing formations are considered in respect to their geographical boundaries, lithological characteristics, economic contents, dip, thickness and other incidental subjects of geological interest.

The Lead Region — Its boundaries and area ; explanation of mining terms ; mineralogy ; section showing the several openings in which ores are found ; present condition of the mines in the various districts of the lead region, giving a description of the location, extent, geological situation, duration of time in which work has been prosecuted, and production of each mining company, so far as the same could be ascertained.

Statistics of the production of lead ore in the various districts since the year 1862, and also the entire production of the lead region, as furnished from the books of the various smelters.

Statistics of the production of zinc ores since its first exportation from the lead region in 1860, prepared from the statements of the manufacturers.

The occurrence of copper in the lead region, with a statement of the amount produced and the localities where found.

V. GEOLOGY OF CENTRAL WISCONSIN. BY ROLAND D. IRVING.

This will embody the results of two years' investigations on the geological structure, topography, economic geology of the heart of the state, including Marathon, Portage, Wood, Clark, Jackson, Juneau, Adams, Waushara, Marquette, northern Columbia and northern Sauk counties; that portion of Green Lake county north of the Fox river, and also of Sauk and Dane counties, except the western row of towns in each. The following is a very brief summary of the contents of the report:

PART I. THE REGION AS A WHOLE. GENERAL SURFACE FEATURES OF CENTRAL WISCONSIN.

(1) RIVER SYSTEMS AND GENERAL SURFACE SLOPES. Wisconsin river system; Black river system; Rock river system; Fox river system. (2) *Surface Reliefs.* Dividing ridges; Baraboo quartzite ranges; outliers and erosion peaks. (3) *Connection between the Geology and Topography of the region.* Opposite effects of the denuding agencies on the Archæan and Paleozoic areas; Drift bearing and driftless areas—their strongly contrasted Topography; Potash Kettles and knobby Drift. (4) *Prairies, Marshes and Timber land.* (5) *Soils of the Region;* their origin and connection with the geological formations. (6) *Resumé;* wherein the foregoing details are grouped together, and the region found to include: 1, the Archæan district of Marathon, Clark, Portage and Wood counties; 2, the great central sand region (itself covering several subordinate areas distinct topographically, viz: the Drift bearing region of Waushara, Marquette, southern Adams, northern Columbia and eastern Sauk counties; the Wisconsin valley, the Black river valley, the Baraboo valley); 3, the limestone district (including the Wisconsin valley, the eastern Columbia district, the elevated prairie belt of southern Columbia and northern Dane, the Sugar river valley, the Catfish valley, the valley of Koshkonong creek). The most marked topographical division to be observed is however that into driftless and drift bearing areas.

GENERAL GEOLOGICAL STRUCTURE OF CENTRAL WISCONSIN, including general descriptions of all the formations; their distribution, thickness, nature, dip, relation to each other; economic contents, etc. It will include also brief discussions as to the cause of the sudden cessation of the drift phenomena along a line crossing midway through the district; on the question of the Huronian age of the Baraboo and Fox River Valley Archæan patches; and on the question of the division of the Potsdam series into two distinct groups, the newer and more calcareous portions lying conformably on the eroded upper surface of the older or non-calcareous beds.

Part II will include detailed descriptions by counties of the formations, topography, ore deposits, clays, building stone, etc., of all of the region examined. Amongst other matters of interest, it will include a detailed description of the kaolin of Wood county; its mode of occurrence, abundance, quality and applicability to industrial purposes.

PART III. CHEMICAL ANALYSES OF ORES, MINERALS, BUILDING STONES, ROCKS AND MINERAL WATERS OF CENTRAL WISCONSIN.

They are the result of the chemical work of E. T. Sweet, for the most part.

MICROSCOPIC EXAMINATIONS OF ROCKS, by C. E. WRIGHT.

VOLUME III.

The precise arrangement of the material of this volume is not yet determined, and only a general outline can now be presented, subject to additions and modifications. It will, perhaps, be found necessary to form two volumes of this material.

I. GEOLOGY OF PALEOZOIC FORMATIONS.

1. Region adjacent to the Mississippi, north of the Wisconsin river. By MOSES STRONG.

2. St. Croix Region. By L. C. WOOSTER.

These reports will relate to the Potsdam, Lower Magnesian, St. Peters, Trenton, and Quatenary formations.

II. GEOLOGY OF THE LAKE SUPERIOR REGION.

1. General geological structure of the region. By R. D. IRVING.

2. Geology of Ashland county. By R. D. IRVING.

3. Iron Bearing Series between Penokee Gap and Nemakagon lake. By CHARLES E. WRIGHT.

4. Copper Bearing Series of Polk, Burnett, Douglas (in part), and Bayfield counties. By M. Strong.

5. Copper Bearing Series of Douglas county (in part). E. T. Sweet.

6. North Central Wisconsin.

III. Menomonee Iron District and adjacent region of Oconto county. By T. B. Brooks and Chas. E. Wright.

IV. Paleontology. By R. P. Whitfield.

The following is an outline of the report on the Menominee Iron Region, prepared by Maj. Brooks:

THE MENOMONEE IRON REGION,

OCONTO COUNTY.

BY T. B. BROOKS,
CHARLES E. WRIGHT AND A. WEICHMANN, ASSISTANTS.

Part I (*Scientific*). The composition, structure and distribution of the Rocks.

Part II (*Practical*). The useful minerals and ores, and how to find and work them.

PART I (SCIENTIFIC). THE COMPOSITION, STRUCTURE AND DISTRIBUTION OF THE ROCKS.

Introduction. A brief general sketch of the Archaean rocks south of Lake Superior, fixing the place and relations of the Menomonee series as Huronian and Iron Bearing.

Chapter I. Detailed plans and sections, with descriptions of the chief localities in which rocks and ores are exposed, with their structure, from actual surveys. Illustrated by numerous large scale plans and sections.

Chapter II. The geographical and topographical position, windings and foldings of the twenty beds comprising the series, teaching where to look for each kind of rock. Illustrated by a general map of the region, with sections.

Chapter III. The composition of the rocks and ores, their varieties, transitions and origin; based on chemical analyses and microscopic study of over 500 specimens. Illustrated by over 150 specimens furnished to the state collections.